TECHNOLOGY DRIVEN PROGRAMME FOR THE DEVELOPMENT OF A FIXED WING MICRO AIR VEHICLE AT NAL

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Date of Birth: *15th August 1947*

Educational Qualifications:
M.E, Turbo machinery I.I.Sc, Bangalore 1973

Professional experience:
» Design and development of Fixed wing and Flapping wing micro air vehicles
» Air circulating system for autoclaves
» Integrally geared Industrial centrifugal compressor - design and development.
» Solar turbine power pack, design, fabrication and testing

Research Interests:
» Flow exploration studies in compressor
» Study of dynamics in compressors
» Research interests in MAV related areas. Low Re flow on airfoils, Morphing/ multifunction airframe/ mini high speed propeller research

Awards / Honors received:
» Two patents at NAL

ABSTRACT

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At NAL, we are developing “Black Kite”- a 300mm span fixed wing autonomous Micro Air Vehicle (MAV) with an endurance of 30 minutes. The first version of this indigenous MAV has been successfully flight-tested in two modes: radio-controlled, and recently, semi-autonomous. The autopilot system used in Black Kite has been developed indigenously and is state-of-the-art. During the development of such an autonomous vehicle, we accommodated for the rapidly improving technology and constantly updated our design to account for this. Especially, the disciplines of material and structural technology, navigation and control using miniature autopilot grew leaps and bounds during the design process time period. Interestingly, some of the technologies became obsolete during this time, and corrective action became necessary. Although the latest trend in technologies enabled improved engineering, the scientific input for the development remained well defined and mostly unaltered. The goal of this paper is to explain the impact of emerging technologies on the development of our modern MAV, “Black Kite”, at NAL.

Several technical challenges were needed to be overcome towards the development of the many subsystems that compose MAV’s. Additional to weight and volumetric concerns, there are important issues such as integration and networking. With respect to the airframe , the fabrication method using BALSA had to be replaced by FRP in the initial phase of the project. Another successive improvement was obtained by using a

carbon composite skeleton airframe with a flexible high strength skin. The required mould drawing prepared using CAD (CATIA and SOLIDWORKS) was directly linked up to the CNC milling machine for the fabrication. In the case of wind tunnel experiments, fabrication of a 10N accurate sting/Floor mounted balance is a challenging task. In the case of power plant, the miniature IC engine power drive was initially replaced by a DC motor and more recently by a brushless DC motor. Worldwide, researchers work on alternative power plants like miniature MEMs-based Gas turbines, tiny Pulsejet and miniature Rotary engines for a power out put 10 to 25 watts. NAL is taking up exploration studies for future solutions. The propeller used in the power plant is of the size between 100-175mm which rotates at 8000 rpm . The present day target is to develop a 2 gram propeller working at an efficiency of 75%. The motor is powered by a Lithium polymer battery of capacity 11.1V/1300mAhr and weighs around 100g. Aeroviournent, USA had used the Li Po based batteries in the form of thin sheets and had made a wing out of this material, called multifunction structure. Similarly other forms of energy input like DMFC fuel cell-based system are being considered as special power sources. A preliminary literature survey indicated the use of Microwave for power transmission so that batteries can be charged during the flight. In the structural aspect of the MAV, one of the considerations is to introduce morphing concept to increase the stall margin and this can be implemented using Flexible structure. Variable camber and chord based design has to be adapted for the effective implementation of wing. NAL is planning to take up this kind of challenging research work under new initiative projects. Another important technology which had gone through a quick change is the Autopilot and its components. The earlier GPS system weighing 30 gram has been replaced by a 5 gram GPS . Similarly we have now MEMs based Gyro/Accelerometers weighing around 2 to 3 grams and this totally changed the scenario of the autopilot development. The payload camera/ transmitter weighing less than 10 grams is available today. All these effort helped us to bring down the size of the MAV to 300mm with a weight budget less 300gram.

Today, new methods and measuring techniques are available for undertaking the research program. e.g. PIV measurements to locate the separation bubble, applications of SMA on morphing the wing structure and use of active vibration control for the platform. We conclude that the technological impact on the development process MAVs is significantly large, demanding aggressive updating of design and fabrication systems to make and fly a competitive MAV. We wish to share the experience, in this direction, gained at NAL during the development of Black kite.

MAVs developed by NAL – different materials and fabrication techniques .

Plastic Sheet with Metal Frame

Complete Balsa Model

Balsa with Plastic sheet

Glass Fiber Model

Carbon composite airframe

Black Kite Fabricated out of Flute board

References

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3. *A Design and Application of Multifunctional structure-battery material systems.* Thomas, James P, Qidwai, Muhammad, JOM, Mar 2005
4. *Development of Micro Air Vehicle Technology with In-flight Adaptive-Wing Structure.* Sergey Shkarayev, William Null, and Matthew Wagner, NASA/CR-2004-213271